

PRELIMINARY GEOTHERMAL ASSESSMENT SURVEYS FOR THE STATE OF HAWAII

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ABSTRACT

The Geothermal Resource Assessment Program of the Hawaii Institute of Geophysics has conducted a series of geochemical and geophysical surveys in ten separate locations within the State of Hawaii in an effort to identify and assess potential geothermal areas throughout the State. The techniques applied include groundwater chemistry and temperatures, soil mercury surveys, ground radon emanometry, time-domain electromagnetic surveys and Schlumberger resistivity soundings. Although geochemical and geophysical anomalies were identified in nearly all the survey sites, those areas which show most promise, based on presently available data, for a geothermal resource are as follows: Puna, Kailua Kona, and Kawaihae on the island of Hawaii; Haiku-Paia and Olowalu-Ukumehame canyons on Maui; and Lualualei Valley on Oahu. Further surveys are planned for most of these areas in order to further define the nature of the thermal resource present.

INTRODUCTION

The Hawaii Institute of Geophysics Geothermal Resource Assessment Program has conducted a series of geochemical and geophysical field surveys in ten prospective geothermal areas of the State of Hawaii to assess their potential. The exploration techniques which have been applied include groundwater chemistry, isotopic analysis, soil mercury and radon surveys, time-domain electromagnetic soundings, and Schlumberger resistivity surveys (Thomas et al., 1980). These surveys were conducted in areas selected from a state-wide assessment of all available data, including the likelihood of subsurface heat from geological criteria, regional geophysics and chemistry of groundwater (Thomas et al., 1979). The areas in which studies have been conducted (Figures 1, 2, and 3) are as follows:

On Hawaii: Kawaihae, Hualalai northwest rift, Kailua Kona, Mauna Loa southwest rift, Kilauea lower east rift, and Kaaui;

On Maui: Kaanapali-Lahaina, Olowalu-Ukumehame and Haiku-Paia;

On Oahu: Lualualei Valley.

SUMMARY OF RESULTS

Kawaihae. Geochemical sampling in the Kawaihae area has delineated an east-west trending zone of anomalously high soil mercury concentra-

tions and ground radon emanation which correlate well with above ambient groundwater temperatures in the immediate vicinity. Groundwater chemistry, specifically Cl/Mg ratios, also indicate that the local groundwater chemistry may have been thermally altered.

Schlumberger resistivity soundings in the Kawaihae area suggest a highly resistive body to the northeast of the mercury and radon anomalies; this feature is interpreted to be a shallow intrusive body which may be associated with a nearby 80,000 year old eruptive vent (Malinowski, 1977).

Although these data indicate potential for low temperature geothermal prospects, further studies will be necessary before any estimate of the thermal potential can be made.

Hualalai Northwest Rift. Geochemical surveys on the northwest flank of Hualalai volcano yielded only very slight evidence of geothermal activity. Soil mercury concentrations and radon outgassing were relatively low throughout the region however slightly elevated mercury concentrations were found to be associated with the eruptive vents along the trend of the rift system; radon values were not significantly anomalous. There are few groundwater wells in this area and thus only two sets of chemical data are available; only one of these, to the south of the rift system, showed a significant Cl/Mg anomaly.

Schlumberger soundings along the rift were able to identify a conductive zone at 500 m depth near the summit of Hualalai; this anomaly has been interpreted to be associated with dike-impounded groundwater which may or may not be above ambient temperatures.

The presently available geochemical and geophysical data do not provide convincing evidence that a thermal anomaly is present in this survey area. However, the last eruptive activity on Hualalai took place in 1801 and it seems likely that this volcano could have some geothermal potential. Continued surveys are planned for Hualalai on a limited scale.

Kailua Kona. Geochemical surveys conducted in the north Kona district have identified several areas in which mercury and radon anomalies are

Fig. 1 Location of Survey Areas: Island of Hawaii

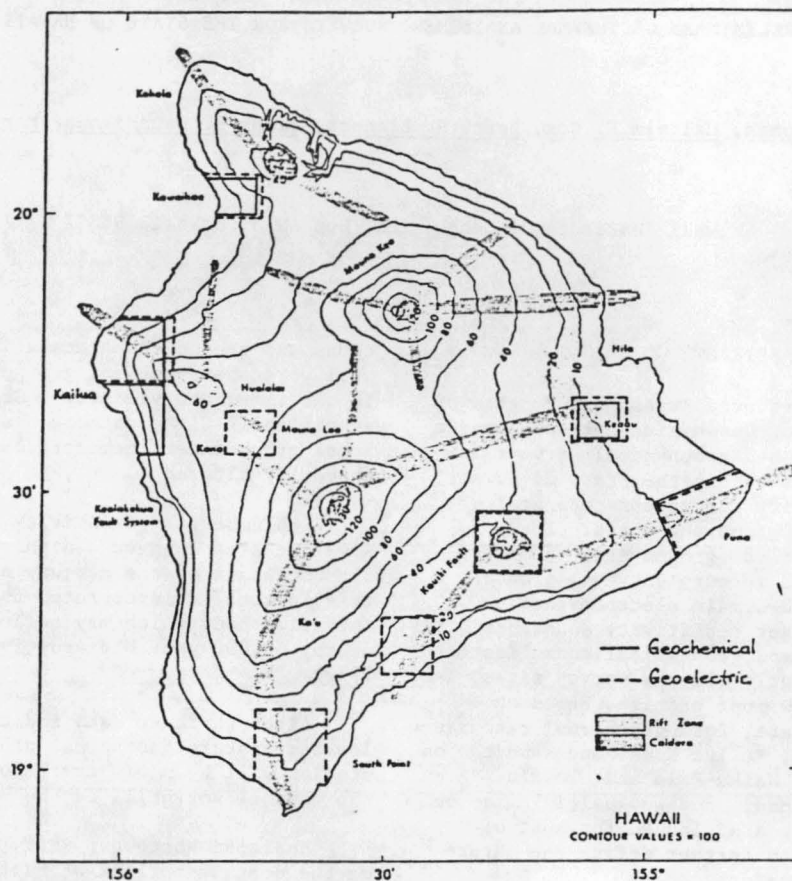


Fig. 2 Location of Survey Areas: Island of Maui

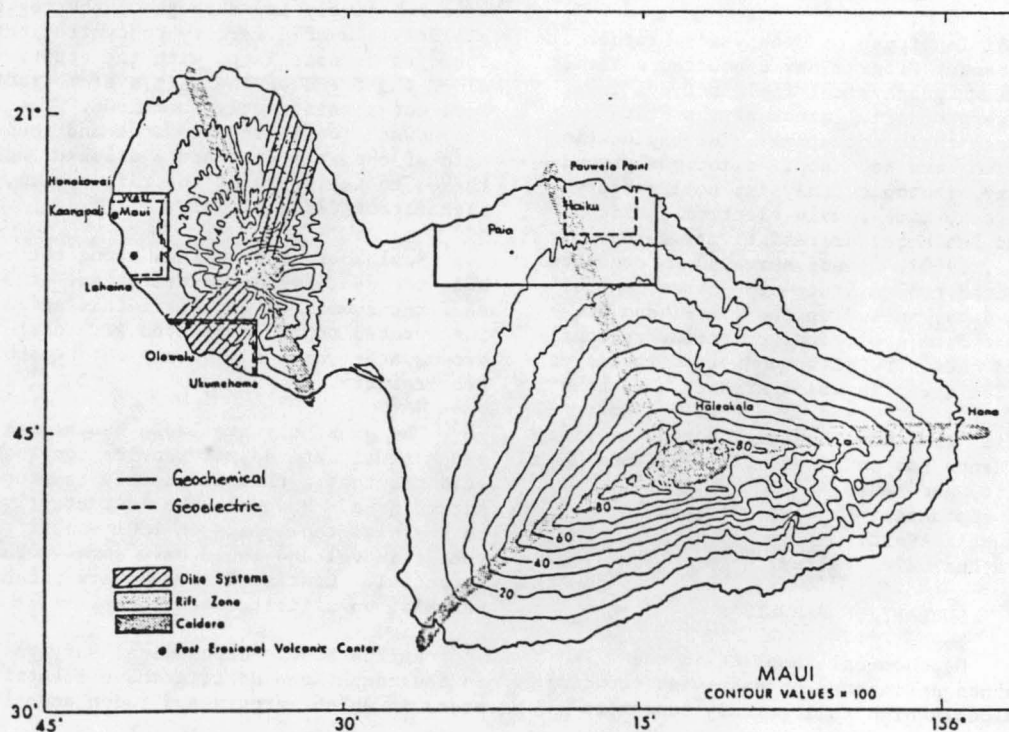
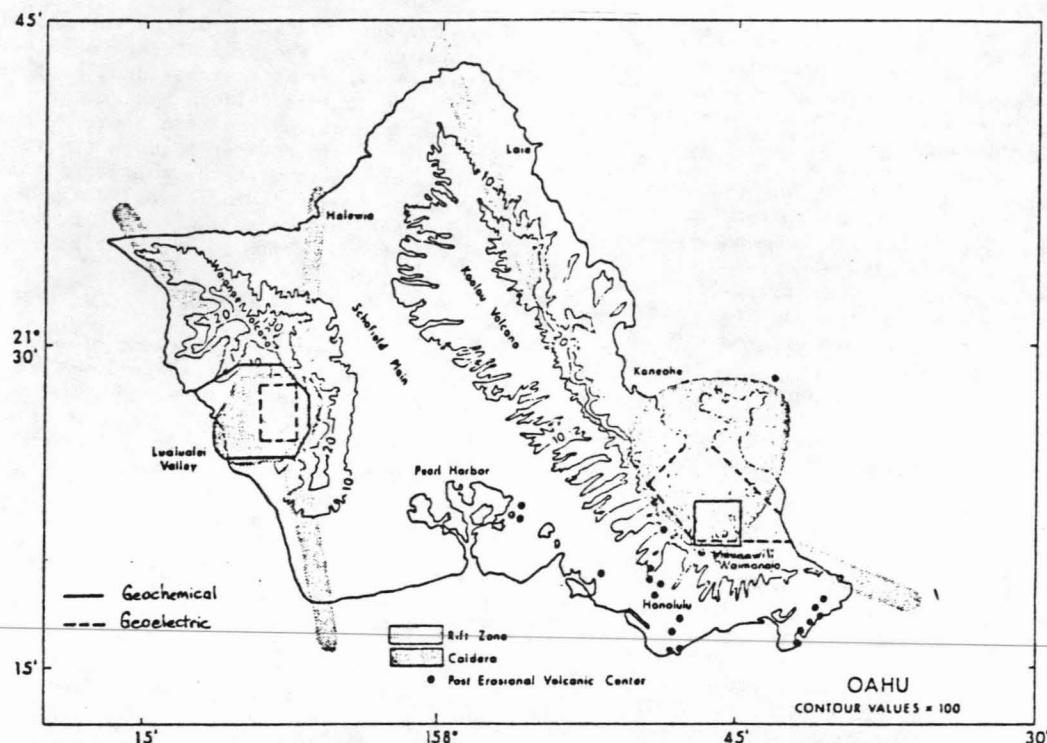


Fig. 3 Location of Survey Areas: Island of Oahu



present. Groundwater Cl/Mg ratios are generally elevated for these areas as well. The general trend of the anomalous zones suggest that they arise from beneath the higher slopes of Hualalai. Geophysical surveys have not yet been conducted in this area, largely due to the extensive pipe networks and other cultural interferences.

Although the presently available data on this area are by no means conclusive, they strongly suggest that thermal anomalies are influencing groundwater chemistry and ground gas movement. Continued surveys will be conducted in this area in an effort to determine whether the origin of the observed anomalies is a local one or is deeper within Hualalai volcano.

Mauna Loa Southwest Rift. Surveys on the lower Mauna Loa southwest rift zone have been restricted to time-domain electromagnetic and Schlumberger resistivity soundings. Estimated resistivities were about 100 ohm-m, suggesting that there is little thermal activity in the immediate survey area.

Keaau. Geochemical and geophysical surveys in the Keaau area were unpromising in regard to geothermal prospects. Mercury and radon surveys showed only slight elevation above the natural background and groundwater chemistry suggested a simple mixing of minor amounts of saline water with local meteoric recharge. Schlumberger and time-domain soundings identified a thick freshwater lens but no anomalous conductors at depths less than 5 km over the entire survey region. Few, if any, geothermal surveys are anticipated for this district of Hawaii.

Kilauea Lower East Rift. Schlumberger and time-domain electromagnetic surveys were completed over several areas of the lower east rift zone of Kilauea in the vicinity of the geothermal well HGP-A. Analysis of the data indicates that this area has a substantially lower resistivity than any of the other survey sites studied and that the HGP-A reservoir is elongated along the strike of the east rift zone and extends to the southeast toward Kapoho (Kauahikaua et al., 1980). Radon and mercury surveys suggest an elongate rift-confined reservoir, with some broadening uprift of HGP-A.

Lahaina-Kaanapali. Water chemistry from several wells in the Lahaina-Kaanapali district shows slightly elevated Cl/Mg ratios suggesting that a low order thermal anomaly may be present in this area; mercury and radon results to some degree substantiate the groundwater data although the anomalies as presently defined are restricted to the immediate vicinity of Kaanapali and a post-erosional cinder cone northeast of Lahaina. Five resistivity soundings were conducted in this area. Resistivities in the order of 20 to 40 ohm-m are interpreted as seawater saturated basalt, which are typical for Hawaii (Mattice & Lienert, 1980).

Our preliminary assessment of this area is that a low temperature anomaly may exist which is associated with the Lahaina post-erosional volcanic centers. Further geochemical and geophysical surveys are currently being carried out to more clearly define the source of the observed anomalies.

Olowalu-Ukumehame. The chemical analyses of three wells in the area are considered anomalous, one having a temperature of 33°C and a Cl/Mg ratio of 17.7 [greater than 15 is considered anomalous for Hawaiian groundwater (Cox & Thomas, 1979)] and two having temperatures greater than 25°C. Soil mercury concentrations are low, but radon survey results show a low order anomaly. Schlumberger resistivity surveys in Olowalu-Ukumehame canyons have identified a conductive layer at a depth of 90 m to 200 m and having a resistivity of 4 ohm-m. These results suggest that the basalts beneath the survey area are saturated with hot seawater (Mattice & Lienert, 1980).

The presence of anomalous groundwater chemistry and resistivities in this area suggests that at least a low temperature thermal anomaly is present.

Haiku-Paia. Groundwater chemical analyses have delineated several areas in which Cl/Mg ratios are substantially higher than normal Hawaiian groundwaters. The highest ratios (21 and 58) are located in the north central corner of the survey area near the intersection of the northwest rift zone of Haleakala and the coast. Groundwater temperatures show a pattern quite similar to that of the Cl/Mg ratios although at higher elevations temperatures decrease, presumably due to the wells penetrating perched groundwater.

Both radon and soil mercury values substantiate the observed anomalous groundwater chemistry and temperature patterns. The highest soil mercury and radon values were found along the western boundary of the rift zone (Cox & Cuff, 1980).

The resistivity values measured in this area average around 10 ohm-m but cannot as yet be ascribed to thermal water and may result from high porosity basalts. It is believed that the very strong geochemical anomalies observed in this area arise from a thermal source associated with the Haleakala northwest rift system. Continued geochemical and geophysical surveys will be conducted in this area to further define the source of heat.

Lualualei Valley. Extensive geochemical surveys have been conducted in the area within and around Lualualei Valley (Cox et al., 1979). Groundwater chemistry data on several wells located near the inferred Waianae Caldera boundary exhibit very strong chemical anomalies: seven wells have temperatures in excess of 25°C, five wells have Cl/Mg ratios in excess of 15, and six wells have silica concentrations greater than 80 ppm. The groundwater chemistry anomalies are generally coincident with strong soil mercury concentrations and ground radon anomalies. Schlumberger soundings in the survey area have identified a dike impounded groundwater layer which appears to overlie basalt saturated with fresh to brackish warm water. This layer is in turn underlain by a highly resistive layer of basement rock which is interpreted to be the dense volcanic intrusive complex associated with the Waianae volcano caldera.

Our interpretation of the results of the geochemical and geophysical data obtained for Lualualei Valley is that residual heat is present within the Waianae Caldera system, probably at considerable depth, and that there is convective transport by groundwater through the fracture system associated with the collapsed caldera. Further geophysical studies and deep drilling will be necessary before estimates can be made of the temperature and depth of the heat source.

CONCLUSION

Our preliminary assessment of the areas presently under study is as follows:

Kawaihae: low to moderate temperatures possibly associated with an ancient intrusion;

Hualalai Northwest Rift: low temperatures may exist but there is presently insufficient data for a more definite appraisal;

Kailua-Kona: a strong indication that subsurface heat has influenced the groundwater chemistry, the source for these anomalies indicated to be below Hualalai volcano;

Mauna Loa Southwest Rift: no indication of any significant subsurface heat;

Kilauea Lower East Rift: surveys suggest that the reservoir tapped by the geothermal well HGP-A extends eastward along the rift zone towards Kapoho;

Keaau: there is a very low probability for a thermal resource in this area;

Lahaina-Kaanapali: surveys suggest that low order anomalous temperatures may be associated with the post erosional Lahaina volcanic vent system;

Olowalu-Ukumehame Canyons: available data have identified what is probably a low to moderate temperature thermal anomaly in Olowalu Canyon;

Haiku-Paia: very strong anomalies, apparently associated with the northwest rift of Haleakala, substantiate the presence of subsurface thermal conditions;

Lualualei Valley: a fracture-controlled low temperature thermal anomaly is indicated within the former Waianae caldera.

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